REMARKS

The foregoing amendments amend the figures 1 and 2 of the drawings, the specification, and claims 4 and 23. New claim 24 is also added and support can be found throughout the Specification and at least in claim 4 as filed. *No new matter is added.*

Amendments to the Drawings and the Specification

The Drawings and Specification have been amended in response to the objections in the Office Action in order to expedite prosecutions of the instant application. *No new matter has been added.*

Amendments to the Claims

In compliance with the Examiner's suggestion, claim 23 has been amended to reflect the further method step "(g)".

As to claim 4, the Examiner rejects the claim under the second paragraph of 35 USC § 112 on the basis that the claim is indefinite. Solely for the purpose of expedited prosecution, Applicant has amended claim 4 to remove the preferred energy range of the collimated X-ray beam.

The Examiner also rejects claims 1, 2, 4-15 and 17-23 on basis that these claims are anticipated by US Patent No. 6,072,853 to Hall *et al.* ("Hall"). Applicant respectfully disagrees with the basis of this rejection. Particularly, claim 1 of the present invention describes a method of analyzing polycrystalline materials where the method includes, among others, step (c) of collimating X-rays from the polychromatic X-ray source into a beam having a divergence in the range of from 10^{-4} to 10^{-2} radians. The Examiner indicates that this step is not novel over Hall and cites Hall at column 3, lines 34-35 and column 4, lines 53-61 in support thereof. However, Applicant notes that Hall, at the indicated column and lines discloses a method of analyzing crystalline mineral materials using X-ray diffraction. In Hall, the polychromatic X-ray photons must have a brightness of 10^{15} photons/sec/mrad^2/0.1% bandwidth and an energy of at least 20 keV. Hall stresses that the sources of X-rays having these characteristics are synchrotrons (column 5, lines 56 and 57). No other sources of X-rays are suggested (except for the speculative mention of plasmas and lasers) and the skilled person would assume, therefore, that it is essential to use a synchrotron in the technique in view of the brightness and energy required.

Synchrotrons produce very intense beams of X-ray radiation having an extremely small divergence. In this regard, the Examiner's attention is drawn to the enclosed extract which shows information drawn from the Handbook on Synchrotron Radiation 1983. The table shows the uncollimated divergence of various synchrotrons at the time of publication of the handbook. The divergence of synchrotron radiation is typically 1×10^{-4} radians or, more commonly, 10^{-5} radians. Indeed, "ESRF" in the table refers to the European Synchrotron Radiation Facility. The Examiner will note that this is one of the suggested synchrotron facilities in the examples of Hall (see column 8, lines 5 to 7) and the divergence of its uncollimated beam is 8×10^{-5} radians.

Importantly, Hall is very clear that the beam of X-rays used in the process must be collimated to reduce its divergence. This is clear from column 4, line 30 and the statement in column 3, lines 31 to 44. This would reduce the divergence of a synchrotron beam to a value of much less than 10^{-4} or 10^{-5} radians, typically to 10^{-6} radians or less.

With the above in mind, the statements in column 4 of Hall can now be put in context. It states here that the X-ray beam needs to be "parallel or very nearly parallel" (see column 4, lines 30 to 44). It goes on further to state that X-rays from a synchrotron will "naturally be very nearly parallel" and that the X-rays emitted from a synchrotron should nevertheless be passed through a sequence of fine slits to ensure that they are "effectively parallel". Therefore, a skilled person reading Hall would interpret "very nearly parallel" on lines 33 and 34 of column 4 to mean a beam that has been generated by a synchrotron and collimated. As the Examiner will appreciate, this would mean a beam having a very small divergence, much less than 10^{-4} radians.

Thus Hall fails to disclose or teach the range in feature (c) of claim 1 of the present application, i.e. from 10^{-4} to 10^{-2} radians.

With reference to pages 1 to 3 of the present application, it will be noted that one of the broad aims of the present invention is to develop a technique that would allow structural and/or chemical characteristics of a polycrystalline engineering material to be determined in an economical manner in a laboratory context. Ideally the method should be adaptable to allow one to analyse a relatively large object, e.g. an engineering component. The technique should ideally avoid any destruction of the object.

As described on page 7, lines 12 to 22 of the present application conventional powdered diffraction techniques require the sample to be in the form of a fine grained powder and therefore require at least the partial destruction of any object being analysed.

It was known before the priority date of the present invention that industrial X-ray sources were available. (Industrial refers to X-ray sources which could be used in a conventional laboratory. It does not include synchrotron radiation facilities, of which there are relatively few throughout the world and are very expensive installations, as explained in Hall, column 5, line 62 to column 6, line 4). However, X-ray beams from industrial sources typically produce polychromatic radiation with a widely divergent cone, as explained in the present application on page 3, lines 16 to 19. The present inventors found that such divergent beams were entirely unsuitable for collecting accurate data from a polycrystalline sample using X-ray diffraction techniques.

The known laboratory techniques such as the Laue method, the rotating crystal method and the powdered method are not suitable for analysing multi-crystalline samples without their destruction, either because a single crystal is required or because the sample must be powdered. These three techniques are described on page 2, lines 15 to 30 of the present application.

In view of the main aim of the present invention to provide a method and apparatus for the determination of the structural and/or chemical characteristics of a polycrystalline engineering material that could be used in a laboratory, it is submitted that the closest prior art is in fact the known X-ray diffraction techniques as listed on page 2, lines 15 to 30. While Hall relates to a method for analysing a crystalline material, it becomes apparent on reading this document that it is essential to use a synchrotron, as explained above. This means that this technique is highly expensive, since one would need to book time on one of the few synchrotron facilities in the world to analyse the sample, and the technique is not transferable to a laboratory context.

The problem in view of the prior art techniques is essentially the aim stated above, i.e. to provide a non-destructive method and apparatus for the determination of structural and/or chemical characteristics of polycrystalline engineering materials, the method and apparatus being suitable for use in a laboratory.

The present inventors surprisingly found that it could solve this problem by using an industrial X-ray source with a divergent cone, by collimating the polychromatic X-ray beam from the source to a narrow divergence of 10^{-4} to 10^{-2} radians and carrying out the method as defined in claim 1. The upper and lower limits have been found by the inventors to enable the successful analysis of engineering materials. It is not possible to obtain accurate data on the lattice parameters and stress measurements of the polycrystalline material where the divergence of the beam is greater than 10^{-2} radians. Additionally, when the beam has a divergence of less than 10^{-4} radians, the intensity of the beam due to the collimation drops to an unusable low level.

There is no indication in the prior art of how one would adapt the conventional X-ray diffraction techniques to arrive at the method of the present invention. The skilled person would not look to Hall for a technique usable in a normal laboratory, since it is clear from this document that the brightness and the energy requirements of the beam means that the use of a synchrotron facility is essential. Even if one were to use such a technique one would still not arrive at the present invention, since the collimated beams of X-rays deriving from a synchrotron source would have a divergence of much less than 10^{-4} radians.

The Examiner has also put forth US Patent No. 5,589,690 to Siewart et al. ("Siewart") as anticipating claims 1, 2, 4-6, 8-15 and 17-23. Applicant respectfully disagrees. The Siewert reference appears to be even less relevant than Hall. Siewert is concerned with monitoring the interface between a molten and solidified crystalline phase in a furnace during a casting process. The disclosed method differentiates between the solid (crystalline) and liquid (amorphous) parts by the nature of the diffraction patterns (i.e. the presence of diffraction peaks from the crystalline phase). Siewert is concerned with monitoring a casting process. It is silent regarding mapping sub-surface stresses and strains in engineering components, which is the focus of the present application.

The method according to Siewert monitors peak intensity, and uses this intensity (peak presence) to make deductions about the location of the liquid-solid interface during the casting process.

The method according to Siewert relies on straight transmission, i.e. absorption imaging (see Figure 1). In contrast, the present application describes x-ray scattering (diffraction) by a Bragg angle that is defined by collimation. Such a set-up is different from Siewert in that it provides beam path definition suitable for quantitative pattern analysis. Unlike Siewert, the

method described in the present application involves the quantitative interpretation of the centre position of crystalline diffraction peaks.

The Examiner has also rejected claims 3, 7 and 16 as being obvious over Siewert and Hall. Claims 3, 7 and 16 are dependent on claim 1 directly or indirectly. As described above, neither Siewert nor Hall teaches or suggests feature (c) in claim 1: collimating X-rays from the polychromatic X-ray source into a beam having a divergence in the range of from 10^{-4} to 10^{-2} radians. All Siewert describes is that the collimated radiation has a plurality of "substantially parallel x-rays" (see column 4, line 46 and column 7, line 12). Such statements provide no quantitative information regarding the beam divergence and do not anticipate the claimed range of 10^{-4} to 10^{-2} radians. These deficiencies are not remedied by Canberra Capabilities Profile Brochure (2002), US Patent No. 4,561,062 to Mitchell *et al.*, or International Application Publication No. WO 91/08372 to Arnott, *et al.*

In view of the above, it is submitted that the method of claim 1, the apparatus of claim 18 and the method of claim 21 and the claims dependent thereon are novel and non-obvious over Hall and Siewert. Accordingly, Applicant respectfully request reconsideration and withdrawal of these rejections.

CONCLUSION

In view of the foregoing amendments and remarks presented, allowance of this application with all pending claims is respectfully requested. If a telephone conversation with Applicant's attorney would expedite prosecution of the above-identified application, the Examiner is invited to call the undersigned at (617) 227-7400.

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